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THE EFFECT OF XYLIDINES ON THE LOAD-CARRYING CAPACITY
OF AN AIRCRAFT-ENGINE OIL - II

By Walter T. Olson and Robert A. Spurr

Aircraft Engine Research Laboratory
Cleveland, Ohio

NACA

WASHINGTON

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MEMORANDUM REPORTTHE EFFECT OF XYLIDINES ON THE LOAD-CARRYING CAPACITY
OF AN AIRCRAFT-ENGINE OIL - II

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SUMMARY

Tests were made to continue a study of the effect of xylidines on the load-carrying capacity of an aircraft-engine oil in several test devices. As part of an investigation on the suitability of xylidines as an antiknock component in aviation gasoline, Navy 1120 lubricating oil, both new and used, and Navy 1120 lubricating oil, both new and used, to which had been added 1 percent by weight of commercial mixed xylidines were tested in a Shell four-ball machine, an Almen machine, an SAE extreme-pressure lubricant-testing machine, and in an NACA bearing-testing attachment. Data from a previous investigation on the effect of a 2-percent addition of xylidines to Navy 1120 lubricating oil in these machines are presented for comparison. The results obtained are summarized in the following table:

PERCENTAGE CHANGE WITH ADDITION OF XYLIDINES TO NAVY 1120 OIL

	Navy 1120 oil plus 2 percent xylidines ^a (percent)	Navy 1120 oil plus 1 percent xylidines (percent)	Used Navy 1120 oil plus 1 per- cent xylidines (percent)
Four-ball Machine:			
Time for 360 rpm deceleration	-3.3	^b 0.55	^b -1.0
Coefficient of sliding friction at contact surfaces	3.4	^b -0.54	^b 0.99
Almen machine:			
Failure load	-15	-17	-14
Coefficient of friction, all loads	35	11	5.0
Wear-scar width	35	0	27
SAE machine:			
Scoring load	-23	-8.7	(c)
NACA attachment:			
Failure load			
Series 1	-5.1	^b 0.81	^b -0.73
Series 2	-2.2	^b -2.8	^b -3.2

^aData from a previous NACA investigation.^bValues are thought to be smaller than experimental error.^cSufficient Timken cups were not available to permit testing of used oil.

The tests with the four-ball machine and the NACA bearing-testing attachment showed no significant change in load capacity on the addition of 1 percent xylidines. The reduction of load capacity on the Almen machine on addition of either 1 or 2 percent xylidines was about 15 percent for both new and used oils; that for the SAE machine with new oil and 1 percent xylidines was about 9 percent. Addition of 1 percent by weight of xylidines decreased the load-carrying ability of new and used Navy 1120 lubricating oil in the Almen and in the SAE machines. It was without significant effect on the performance of new and used Navy 1120 oil in the Shell four-ball machine and in the NACA bearing-testing attachment.

INTRODUCTION

The tests of this report are a part of an investigation conducted at the request of the Army Air Forces on the suitability of xylidines as an antiknock component in aviation gasolines. The work reported is a continuation of a previously published study (reference 1) of the effect of xylidines on the load-carrying capacity of an aircraft-engine oil. Specifically, Navy 1120 lubricating oil, both new and used, and Navy 1120 lubricating oil, both new and used, to which had been added 1 percent by weight of a commercial xylidine mixture were tested in four test devices. Data from reference 1, which show the effect of 2-percent addition of xylidines on the load-carrying capacity of new Navy 1120 oil, are also included.

The tests were conducted at the Aircraft Engine Research Laboratory, National Advisory Committee for Aeronautics, Cleveland, Ohio, during July and August 1943.

TYPES OF OIL

New and used Navy 1120 lubricating oil and blends of each of these oils with 1 percent by weight of a commercial xylidine mixture were used in the tests. The used oil had lubricated for about 200 hours a 14-cylinder radial air-cooled engine operated in a variety of test programs. Make-up oil had been added to the original 250 gallons in the circulating system at the rate of about 10 gallons every 8 hours. The results of laboratory inspection of the used oil are as follows:

ANALYSIS OF USED NAVY 1120 OIL

[Conversion of viscosity in centistokes to viscosity in Saybolt seconds by A.S.T.M. designation D 446-39; viscosity index by A.S.T.M. designation D 567-40 T]

Temperature (°F)	Kinematic viscosity (centistokes)	Saybolt universal viscosity (sec)
100	364.1	1682
210	24.9	116
Viscosity index	93	
Naptha insoluble, percent	.62	
Chloroform soluble, percent	.12	
Neutralization number	.12	
Conradson carbon, percent	1.35	

APPARATUS AND TEST PROCEDURE

The apparatus employed, namely, a Shell four-ball machine, an Almon machine, an SAE extreme-pressure lubricant-testing machine, and an NACA bearing-testing attachment, and the test procedures followed were the same as those described in reference 1.

RESULTS AND DISCUSSION

The Shell four-ball machine. - The results of the tests are shown in figure 1 and in the following table:

Type of oil	Average time for 360 rpm deceleration (min) ^a	Average coefficient of sliding friction at contact surfaces
Navy 1120 oil ^b	2.220±0.011	0.1109±0.0006
Navy 1120 oil plus 2 percent xylidines ^b	2.147±0.019	0.1147±0.0010
Navy 1120 oil	2.362±0.017	0.1034±0.0008
Navy 1120 oil plus 1 percent xylidines	2.375±0.009	0.1027±0.0004
Used Navy 1120 oil	2.412±0.012	0.1012±0.0006
Used Navy 1120 oil plus 1 percent xylidines	2.387±0.005	0.1022±0.0002

^aAverage of five runs.

^bData from reference 1.

As can readily be seen from figure 1, the addition of 1 percent by weight of xylidines had no significant effect on the coefficient of sliding friction with either new or used Navy 1120 oil. The averages for the deceleration times for the runs before the addition of 1 percent xylidines, as shown in the table, differ from those after the addition by amounts that are of the order of the probable errors. The addition of 2 percent xylidines increased the coefficient of sliding friction with Navy 1120 oil by about 3 percent (reference 1).

The coefficients of sliding friction obtained with the used oil are slightly lower than those obtained with the new oil. The difference between the coefficients of friction obtained with new Navy 1120 oil for this paper and for reference 1 can be explained at least in part by the fact that different sets of balls in different stages of wear were used.

The Almen machine. - The average Almen test results and their probable errors as determined from 10 runs with each oil sample were as follows:

Type of oil	Average failure load (lb/sq in.)	Coefficient of sliding friction at 1000 lb/sq in.	Average coefficient of sliding friction (all loads)	Average width of wear scar (in.)
Navy 1120 oil ^a	4100±580	0.17	0.17±0.01	0.049±0.010
Navy 1120 oil plus 2 percent xylidines ^a	3500±370	.23	0.23±0.01	0.066±0.021
Navy 1120 oil	4200±400	0.20	0.19±0.01	0.035±0.004
Navy 1120 oil plus 1 percent xylidines	3500±440	.20	0.21±0.01	0.035±0.007
Used Navy 1120 oil	5100±770	0.21	0.20±0.01	0.033±0.007
Used Navy 1120 oil plus 1 percent xylidines	4400±440	.22	0.20±0.01	0.042±0.012

^aData from reference 1.

In the Almen test the effect of 2 percent xylidines added to new Navy 1120 oil was to decrease the failure load by about 15 percent, increase the coefficient of sliding friction by about 35 percent, and increase the wear-scar width by about 35 percent (reference 1). The effect of 1 percent xylidines added to new Navy 1120 oil was to decrease the failure load by about 17 percent, increase the coefficient of sliding friction by about 11 percent, and cause no

observable variation in the average wear-scar width. The effect of 1 percent xylidines added to used Navy 1120 oil was to decrease the failure load by about 14 percent, increase the coefficient of sliding friction by about 5 percent, and increase the wear-scar width by about 27 percent.

The discrepancies in the results of tests on new Navy 1120 oil for this paper and for reference 1 may be ascribed to variation in the composition of the oil and to experimental error.

The addition of xylidines decreased the load-carrying ability of Navy 1120 oil in every case tested in the Almen machine. It is of interest to note that the used oils exhibited slightly greater load-carrying capacity than did the new oils.

The SAE extreme-pressure lubricant-testing machine. - The average scoring loads and their probable errors in the SAE machine tests were as follows for 10 runs on each sample:

	Scale reading (lb)
Navy 1120 oil (reference 1)	138±12
Navy 1120 oil plus 1 percent xylidines	126±21
Navy 1120 oil plus 2 percent xylidines (reference 1)	106±4

The effect of xylidines was to decrease the load-carrying ability of new Navy 1120 oil by about 8.7 percent for a 1-percent addition and by about 23 percent for a 2-percent addition. Although the effect of a 2-percent addition of xylidines was probably outside experimental error, as shown by the fact that the difference between the scoring loads for the two oils was four times the mean probable error for those two observed loads, the effect of a 1-percent addition of xylidines was, by the same criterion, hardly greater than the experimental error.

Sufficient Timken test cups were not available to permit testing used oils in the SAE machine.

The NACA bearing-testing attachment. - The results of the two tests on the new oil are shown in figure 2 and those of the two tests on the used oil are shown in figure 3. It is evident that no conclusion can be drawn as to the effect of the addition of 1 percent of xylidines on the load-carrying capacity of the oils. The averages for the 10 runs before and after addition in each series of runs are given in the following table:

Type of oil	Average failure load (lb/sq in. of projected area)	
	Series 1	Series 2
Navy 1120 oil ^a	3160±7	2985±24
Navy 1120 oil plus 2 percent xylidinos ^a	3000±17	2920±9
Navy 1120 oil	2473±15	2862±38
Navy 1120 oil plus 1 percent xylidines	2493±30	2783±31
Used Navy 1120 oil	3166±14	3050±36
Used Navy 1120 oil plus 1 percent xylidines	3143±57	2952±34

^aData from reference 1.

The tests of reference 1 showed that the addition of 2 percent by weight of xylidines decreased the load-carrying capacity in this machine by about 4 percent. In these tests an average decrease in load capacity of 1 percent resulted for the new oil and 2 percent for the used oil on the addition of 1 percent xylidines. These values are, however, probably without significance on account of the large scatter of the experimental points.

Inasmuch as the load capacity found for an oil in the bearing machine depends on the previous history of the bearing, only those values obtained immediately before and after the addition of xylidines should be compared. Each pair of averages of 10 such values is enclosed between the horizontal rules in the table.

CONCLUSIONS

The results of these tests are what might have been expected from a consideration of the work of reference 1. The effect of the addition of 2 percent xylidines on the performance of new Navy 1120 oil was very small in the four-ball and the bearing-testing machines. When only 1 percent xylidines was added, the effect was lost in experimental error. For the other two machines the effect of the

addition of 1 percent xylidines on the variables measured was somewhat less, in general, than that of adding 2 percent xylidines. The behavior of the used Navy 1120 oil was similar to that of the new oil.

Aircraft Engine Research Laboratory,
National Advisory Committee for Aeronautics,
Cleveland, Ohio, September 11, 1943.

REFERENCE

1. Spurr, Robert A., and Olson, Walter T.; The Effect of Xylidines on the Load-Carrying Capacity of an Aircraft-Engine Oil - I. Memo. rep., NACA, Aug. 2, 1943.

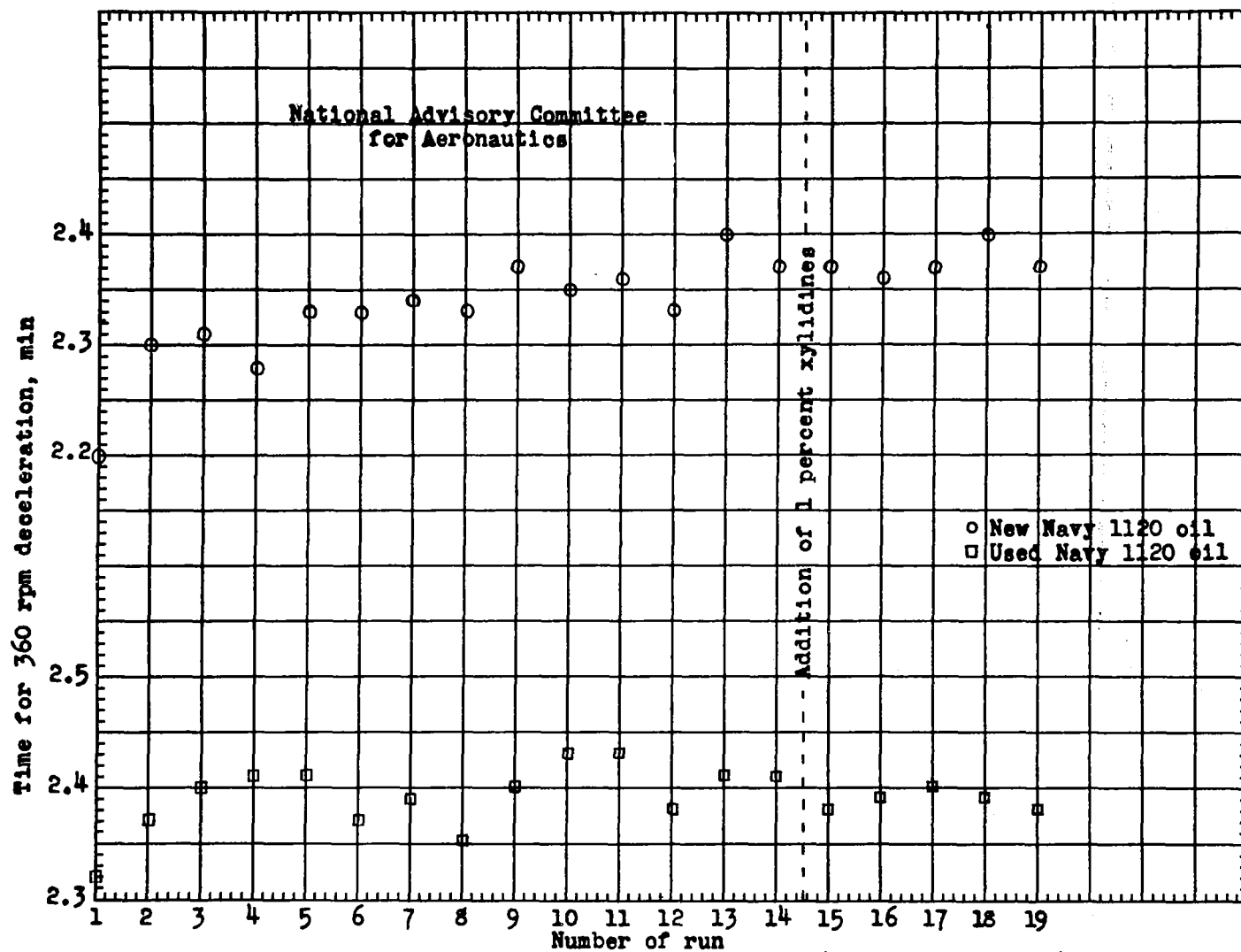


Figure 1. - Effect of 1 percent by weight of xylidines (added after run 14) on the time of deceleration of a Shell four-ball wear top from 720 to 360 rpm. Weight of top, 30.75 pounds; diameter of steel balls 1/2 inch.

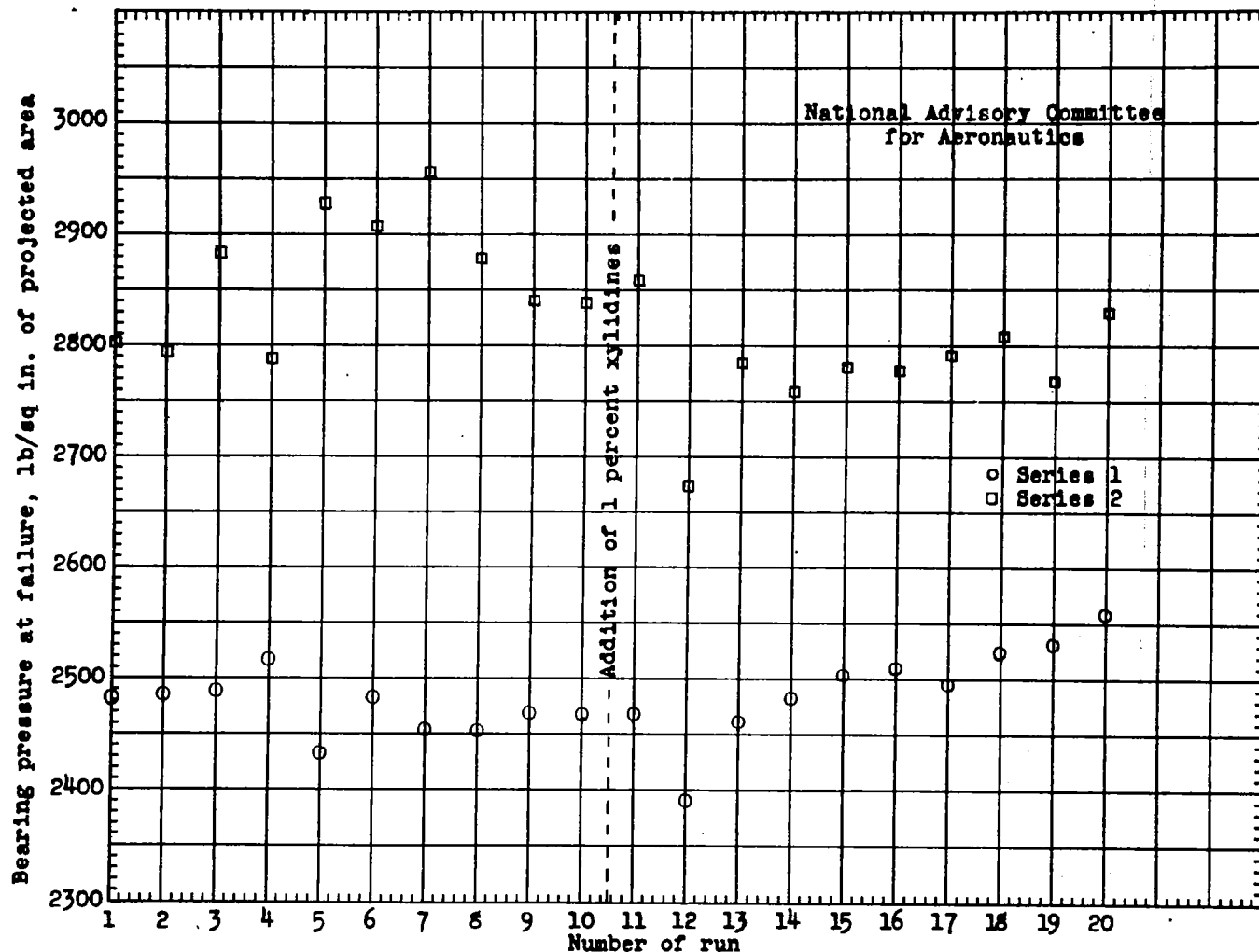


Figure 2. - Effect of 1 percent by weight of xylidines (added after run 10) on the load-carrying capacity of new Navy 1120 oil in a 1 3/16- by 1 3/16-inch bronze bearing. NACA bearing-testing attachment; oil-in temperature: series 1, 147° F; series 2, 151° F; oil pressure: series 1, 60 pounds per square inch; series 2, 32 pounds per square inch; loading speed, 6000 pounds per minute; speed, 1708 rpm.

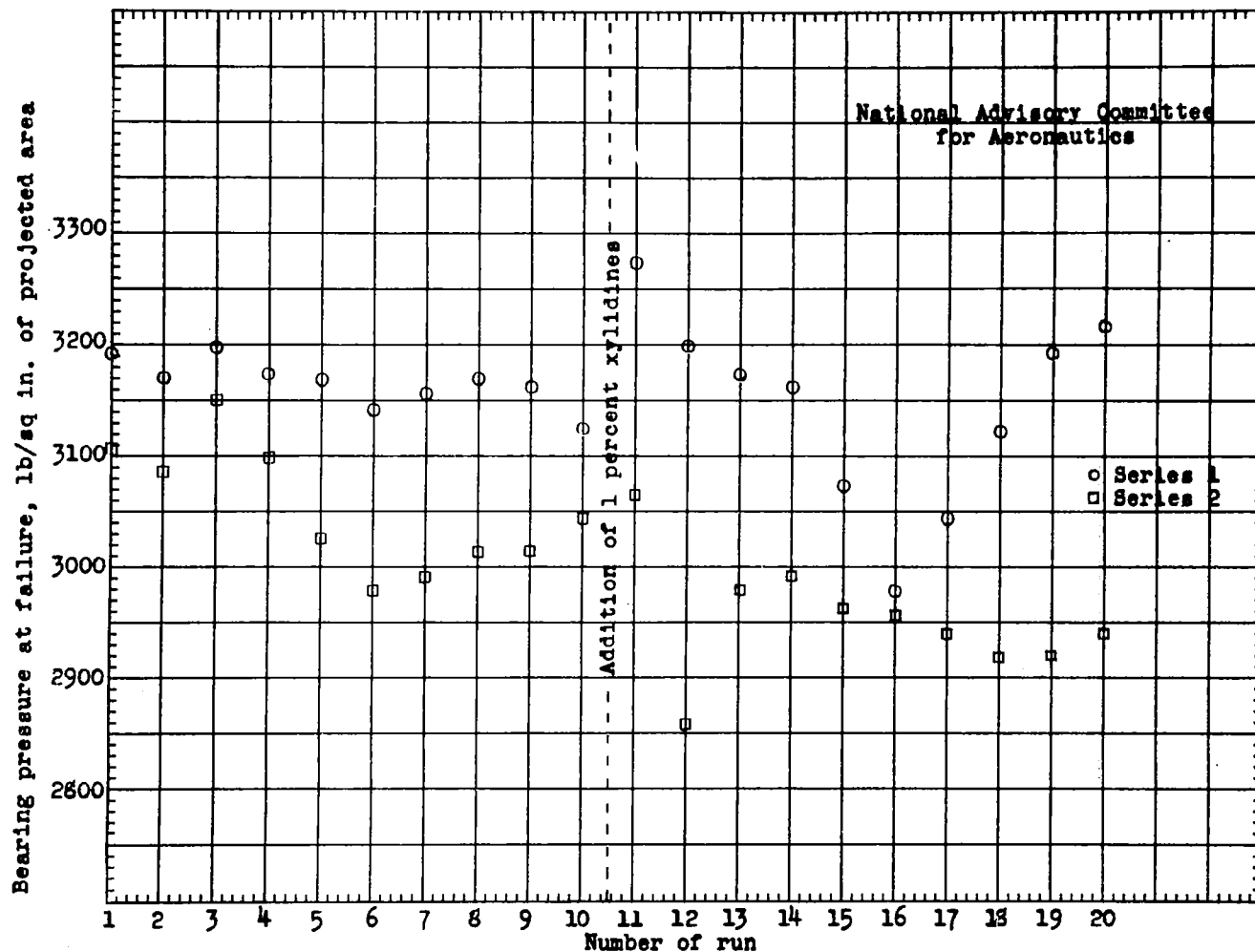


Figure 3. - Effect of 1 percent by weight of xylidines (added after run 10) on the load-carrying capacity of used Navy 1120 oil in a 1 3/16- by 1 3/16-inch bronze bearing. NACA bearing-testing attachment; oil-in temperature: series 1, 147° F; series 2, 145° F; oil pressure: series 1, 32 pounds per square inch; series 2, 35 pounds per square inch; loading speed, 6000 pounds per minute; speed, 1705 rpm.

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